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Weed dynamics and system productivity under rice-based cropping system

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ABSTRACT

An experiment was carried out during 2008-09 and 2009-10 at Jagdalpur, Chhattisgarh to determine the influence of rice-based cropping system on the weed dynamics. The rice-fallow system had the higher density (1364 and 1435/m^2) of *Echinochloa colona*, which was gradually reduced with increasing cropping intensity and the lowest density was under rice-garden pea system (20.0 - 20.9/m^2). Increasing irrigation frequency increased the density of *E. colona*. In *Rabi* season, rice-wheat and rice-garden pea cropping systems were found highly infested with weeds as compared to rice-fallow, rice-chickpea and rice-summer maize systems. The highest rice equivalent yield was recorded under rice-chickpea (7.20-7.76 t/ha) cropping system.

Keywords: Cropping system, System productivity, Weed density, Weed dynamics

Rice production constitutes the major economic activities and key source of livelihood for the rural households of Southern Chhattisgarh. In Chhattisgarh, rice occupies average of 3.6 million ha with the productivity ranging between 1.2-1.6 t/ha depending upon the rainfall. The state is popularly recognized as rice bowl of the country as rice is the principal crop and about 69.7% of net sown area is covered under *Kharif* rice. Fallowing of lands is common but recent demand of food security leads to take succeeding crops in system to make it profitable. However, some farmers do grow winter crops like wheat, garden pea, chickpea, summer maize depending on the irrigation facilities available. Weed infestation in field increases demand for available resources management of weeds is of paramount importance in all respect to achieve desirable yield. But, labour engagement for weeding is costly because of non-availability of labours in time which leads farmers to use herbicides. Weed dynamics vary largely due to cropping system and moisture availability and reduce crop yields ranging from 30 to 100% in wheat, 20 to 60 % in chickpea 10 to 45% (Pradhan *et al*. 2014). There is urgent need to combat the weed infestation in cropping system to increase the system productivity.

MATERIALS AND METHODS

The field experiment was conducted during 2008-09 and 2009-10 at S.G. College of Agriculture and Research Station, Jagdalpur (Chatttisgarh). The soil was sandy loam in texture, low in organic carbon (0.43%) available N (178 kg/ha) and available phosphorus (21.4kg/ha) and medium in available potassium (179 kg/ha) with normal in reaction (pH 6.8). The experiment was laid out in a split-plot design by keeping five cropping systems, *viz.* rice-fallow, rice-wheat, rice-garden pea, rice-chickpea and rice-summer maize) in main plots and three irrigation levels, *viz.* 2, 4 and 6 irrigation frequency in sub-plots repeating four times. Transplanting of rice seedlings was done on 26 July, 2008 and 20 July, 2009 and harvested on 2 December, 2008 and 30 November, 2009, respectively.

The succeeding winter crops were sown after harvest of rice. Summer maize was sown during the first week of January. Recommended package of practices of the region except irrigation was adopted for all the crops. The irrigation frequency was maintained equally for each crop as 2 irrigations (at sowing and before flowering stage), 4 irrigations (at sowing, tillering/branching, before flowering and milking stage) and 6 irrigations (at sowing, tillering/branching, late tillering, flowering, milking and dough stages). Chickpea crop was also irrigated two times to homogenize the treatment affects. Weed sample were collected by random placing of 50 x 50 cm quadrate in each plot at monthly interval. Weeds were cut down at ground levels and then identified, counted and the samples were kept in an oven at 70$\pm$1 ^{o}C until they attained constant weight. The crop growth and yield attributing characters were also recorded at different stages of crop. The data on weeds were transformed with square root transformation $\sqrt{x + 0.5}$ for statistical analysis.

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RESULTS AND DISCUSSION

Density of weeds

Different cropping system had significant effect on density of weeds during different seasons. In rice-fallow cropping system, higher density of *Echinochloa colona* was recorded which, reduced gradually with increasing cropping intensity. The lowest density of *Echinochloa colona* was noticed under rice-garden pea system (20.0/m^2 and 20.9/m^2) during both the years of experimentation. The irrigation frequency also showed significant impact on dynamics of weed density having higher density with more number of irrigation frequencies while, two irrigations had lower density of *Echinochloa colona* which, was increased upto six irrigations (26.0 and 27.2/m^2). Both the cropping systems reduced the density of *Echinochloa colona* whereas irrigation frequency increased the density of weeds. *Cyperus iria* was also suppressed by cropping system, but no significance difference in density of *C. iria* under rice-fallow, rice-wheat, rice-chickpea and rice-summer maize was recorded. The rice-garden pea attained lower density of *Cyperus iria* (16.7/m^2).

In *Rabi* season, some prominent weeds were *Chenopodium album, Medicago denticulata, Polygonum plebieum, Echinochloa colona* and *Medicago alba.* Among the cropping systems, rice-wheat and rice-garden pea cropping systems were found infested with high number of *Rabi* season weeds as compared to rice-fallow, rice-chickpea and rice-summer maize system of cropping. *Chenopodium album, Medicago denticulata, Polygonum plebieum, Echinochloa colona* and *Melilotus alba* were higher in dominancy among the weeds. *Medicago denticulata* was found significantly higher under rice-wheat cropping system (1364 and 1435/m^2) and tremendously suppressed the yield of wheat along with other weed flora followed by rice-chickpea (65.0 and 68.4/m^2). Similar trends were observed in case of *Chenopodium album, Polygonum plabeium, Echinochloa colona* and *Melilotus alba*, which were significantly higher over remaining cropping systems except rice-garden pea where *Polygonum plabeium* was at par with that of rice-wheat cropping system (136.0 and 143.0 m^2) during both the years (Table 1). This might be due to proper availability of moisture to the plants. Similar results were reported by Patil and Sheelavantar (2004) and Chiroma *et al.* (2006).

The irrigation frequency significantly influenced the weed density in *Rabi* season in 2008-09 as well as 2009-10. The *Ammannia baccifera* and *Commelina benghalensis* were found in higher density under rice-fallow, rice-wheat, rice-garden pea cropping system and showed no significant differences, but in rice-chickpea and rice-summer maize density of both the weeds was found significantly lower during *Kharif*

Table 1. Weed density (no./m^2) as influenced by rice-based cropping system during *Rabi* season

Treatment	*Chenopodium album*		*Medicago denticulata*		*Polygonum plabeium*		*Echinochloa colona*		*Melilotus alba*		Others	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
Cropping system												
Rice-fallow	25.0 (5.05)	26.3 (5.18)	20.0 (4.53)	21.0 (4.64)	15.0 (3.94)	15.8 (4.03)	9.0 (3.08)	9.5 (3.16)	10.0 (3.24)	10.5 (3.32)	17.5 (4.24)	18.0 (4.74)
Rice-wheat	52.0 (7.25)	54.7 (7.43)	1365.0 (36.95)	1435.3 (37.89)	136.0 (11.68)	143.0 (11.98)	21.0 (4.64)	22.1 (4.75)	125.0 (11.20)	131.4 (11.49)	132.5 (11.53)	138.9 (11.81)
Rice-garden pea	60.0 (7.78)	63.1 (7.97)	65.0 (8.09)	68.3 (8.30)	89.0 (9.46)	93.6 (9.70)	3.0 (1.87)	3.1 (1.91)	20.0 (4.53)	21.0 (4.64)	27.5 (5.29)	28.5 (5.39)
Rice-chickpea	45.0 (6.75)	47.3 (6.92)	35.0 (5.96)	36.8 (6.11)	68.0 (8.28)	71.5 (8.49)	2.0 (1.58)	2.1 (1.61)	39.0 (6.28)	41.0 (6.44)	46.5 (6.86)	48.5 (7.00)
Rice-summer maize	10.0 (3.24)	10.5 (3.32)	25.0 (5.05)	26.3 (5.18)	10.0 (3.24)	10.5 (3.32)	10.0 (3.24)	10.5 (3.32)	2.0 (1.58)	2.1 (1.61)	9.5 (3.16)	9.6 (3.18)
LSD(P=0.05)	0.77	3.61	NS	NS	2.22	2.28	1.40	1.43	1.64	NS	NS	NS
Irrigation frequency												
2 irrigation	55.0 (7.45)	57.8 (7.64)	68.0 (8.28)	71.5 (8.49)	92.0 (9.62)	96.7 (9.86)	18.0 (4.30)	18.9 (4.41)	20.0 (4.53)	21.0 (4.64)	27.5 (5.29)	28.5 (5.39)
4 irrigation	42.0 (6.52)	44.2 (6.68)	55.0 (7.45)	57.8 (7.64)	62.0 (7.91)	65.2 (8.10)	9.0 (3.08)	9.5 (3.16)	(14.0 (3.81)	14.7 (3.90)	21.5 (4.69)	22.2 (4.77)
6 irrigation	30.0 (5.52)	31.5 (5.66)	28.0 (5.34)	29.4 (5.47)	45.0 (6.75)	47.3 (6.92)	5.0 (2.35)	5.3 (2.40)	9.0 (3.08)	9.5 (3.16)	16.5 (4.12)	17.0 (4.18)
LSD(P=0.05)	1.00	1.02	2.11	2.18	1.17	1.18	0.73	0.76	0.73	0.75	0.58	0.60

The data in parentheses were transformed with square root transformation $\sqrt{x + 0.5}$

season of 2008-09 and 2009-10, respectively (Table 1). Other weed flora also contributed significantly in density in both the years. There was no statistical difference between rice-fallow and rice-wheat cropping system in case of both the weeds, but it was lower when rice-garden pea, rice-chickpea and rice-summer maize cropping systems were taken in cultivation wherein lowest level of weeds was observed under rice-chickpea than other crops of *Rabi* season. The lower density of weeds was noticed under rice-fallow and rice-summer maize because lands were not used under continuous cultivation as rice-fallow in *Rabi* season led to lower density only on residual moisture.

The irrigation frequency for crops had drastic change in weed pattern from 2 to 6 irrigations. Under two irrigations, all weeds in *Kharif* season were noticed lower but increased significantly with four irrigation whereas under six irrigation, highest weed density was recoded which were still comparable to that of four irrigation during both the years. The higher level of irrigations had higher level of weed dominancy regardless the weed flora prevalent. The six irrigation and four irrigations were at par with each other in case of *Chenopodium album, M. denticulata, P. plabeium, E. colona* and *Melilotus alba* (Table 2).

Dry weight of weeds

In *Kharif* season, dry weight of weed was influenced significantly by cropping system and irrigation frequency because of association of weeds and availability of nutrients along with water. *Echinochloa colona* and *Cyperus iria* were identical in attaining dry weight under rice-fallow, rice-wheat and rice-chickpea cropping system, where dry weight was higher as compared to rice-garden pea and rice-summer maize cropping systems due to availability soil moisture in case of fallow and wheat. Under fallow, moisture depleted slowly because of no interfere of soil profile which promoted growth of weeds but when wheat cultivation was done by conventional tillage, although moisture was lost, yet it was compensated by frequent irrigation. On the other hand, in rice-chickpea cropping system, less disturbed and frequent irrigations also helped to retain moisture longer than other cropping to conserve seed banks for coming season (Table 3). This finding is in line with those of Ghadage *et al*. (2006). *Ammannia baccifera* and *Commelina benghalensis* were also found under similar level of suppression in all cropping systems except rice-summer maize system of cropping due to longer vacant period of moisture absence in field during winter after rice harvest. Other weeds were not affected significantly by rice-fallow and rice-wheat cropping systems. In case of irrigation frequency, two irrigations reduced the dry matter of weeds which was significantly lower than four and six irrigation. Both the irrigations equally increased the dry matter of weeds during *Kharif* 2008-09 and 2009-10, in care of *E. colona, Cyperus iria, Ammania beccifera, Commelina benghalensis* and even of other weeds (Table 3). Fre-

Table 2. Weed density (no./m^2) as influenced by rice-based cropping system during *Kharif* season

Treatment	*Echinochloa colona*		*Cyperus iria*		*Ammannia baccifera*		*Commelina beghalensis*		Others	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
Cropping system										
Rice-fallow	30.0 (5.52)	31.3 (5.64)	25.0 (5.05)	26.1 (5.16)	10.0 (3.24)	10.4 (3.31)	6.0 (2.55)	6.3 (2.60)	10.0 (3.24)	10.4 (3.31)
Rice-wheat	28.0 (5.34)	29.3 (5.46)	18.0 (4.30)	18.8 (4.39)	9.0 (3.08)	9.4 (3.15)	5.0 (2.35)	5.2 (2.39)	8.0 (2.92)	8.4 (2.98)
Rice-garden pea	20.0 (4.53)	20.9 (4.63)	16.0 (4.06)	16.7 (4.15)	6.0 (2.55)	6.3 (2.60)	4.0 (2.12)	4.2 (2.16)	7.0 (2.74)	7.3 (2.80)
Rice-chickpea	25.0 (5.05)	26.1 (5.16)	20.0 (4.53)	20.9 (4.63)	8.0 (2.92)	8.4 (2.98)	6.0 (2.55)	6.3 (2.60)	5.0 (2.35)	5.2 (2.39)
Rice-summer maize	22.0 (4.74)	23.0 (4.85)	24.0 (4.95)	25.1 (5.06)	5.0 (2.35)	5.2 (2.39)	3.0 (1.87)	3.1 (1.91)	7.0 (2.74)	7.3 (2.80)
LSD(P=0.05)	0.61	0.53	0.75	0.77	0.69	0.33	0.43	0.21	0.32	0.33
Irrigation frequency										
2 irrigation	12.0 (3.54)	12.5 (3.61)	15.0 (3.94)	15.7 (4.02)	8.0 (2.92)	8.4 (2.98)	6.0 (2.55)	6.3 (2.60)	9.0 (3.08)	9.4 (3.15)
4 irrigation	18.0 (4.30)	18.8 (4.39)	25.0 (5.05)	26.1 (5.16)	12.0 (3.54)	12.5 (3.61)	9.0 (3.08)	9.4 (3.15)	11.0 (3.39)	11.5 (3.46)
6 irrigation	26.0 (5.15)	27.2 (5.26)	29.0 (5.43)	30.3 (5.55)	13.0 (3.67)	13.6 (3.75)	10.0 (3.24)	10.4 (3.31)	12.0 (3.54)	12.5 (3.61)
LSD(P=0.05)	0.85	0.87	0.39	0.40	0.14	0.15	0.16	0.17	0.15	0.16

The data in parentheses were transformed with square root transformation $\sqrt{x + 0.5}$

quency of irrigation increased the dry mater owing to greater availability of resources at certain intervals. Similar findings have also been reported by Chhokar *et al.* (2007).

In *Rabi* season, different weeds were observed short stature except *Echinochloa colona* and *Setria glauca* in fields. *Chenopodium album* had significantly lower dry matter (8.75g/m^2) under rice-follow and rice-summer maize cropping as compared to the rest of cropping systems where dry matter was identical in statistical scale in reducing accumulation during 2008-09 and 2009-10 (Table 4). The weeds like *M. denticulata, Polygonum plabeium, E. colona* and *M. alba* were very prominent in *Rabi* season and found

Table 3. Dry weight of weeds (g/m^2) influenced by rice-based cropping system during *Kharif* season

Treatment	*Echinochloa colona*		*Cyperus iria*		*Ammannia baccifera*		*Commelina benghalensis*		Others	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
Cropping system										
Rice-fallow	10.5	11.0	8.75	9.15	3.50	3.66	2.10	2.19	3.50	3.66
	(3.32)	(3.39)	(3.04)	(3.11)	(2.00)	(2.04)	(1.61)	(1.64)	(2.00)	(2.04)
Rice-wheat	9.80	10.24	6.30	6.58	3.15	3.29	1.75	1.83	2.80	2.93
	(3.21	(3.28)	(2.61)	(2.66)	(1.91)	(1.95)	(1.50)	(1.53)	(1.82)	(1.85)
Rice-garden pea	7.00	7.32	5.60	5.85	2.10	2.19	1.40	1.46	2.45	2.56
	(2.74)	(2.80)	(2.47)	(2.52)	(1.61)	(1.64)	(1.38)	(1.40)	(1.72)	(1.75)
Rice-chickpea	8.75	9.15	7.00	7.32	2.80	2.93	2.10	2.19	1.75	1.83
	(3.04)	(3.11)	(2.74)	(2.80)	(1.82)	(1.85)	(1.61)	(1.64)	(1.50)	(1.53)
Rice-summer maize	7.70	8.05	8.40	8.78	1.75	1.83	1.05	1.10	2.45	2.56
	(2.86)	(2.92)	(2.98)	(3.05)	(1.50)	(1.53)	(1.24)	(1.26)	(1.72)	(1.75)
LSD(P=0.05)	0.35	0.36	0.38	0.46	0.43	0.40	0.24	0.37	0.23	0.22
Irrigation frequency										
2 irrigation	4.2	4.39	5.25	5.49	2.80	2.93	2.10	2.19	3.15	3.29
	(2.17)	(2.21)	(2.40)	(2.45)	(1.82)	(1.85)	(1.61)	(1.64)	(1.91)	(1.95)
4 irrigation	6.30	6.58	8.75	9.15	4.20	4.39	3.15	3.29	3.85	4.03
	(2.61)	(2.66)	(3.04)	(3.11)	(2.17)	(2.21)	(1.91)	(1.95)	(2.09)	(2.13)
6 irrigation	9.10	9.51	10.15	10.61	4.55	4.76	3.50	3.66	4.20	4.39
	(3.10)	(3.16)	(3.26)	(3.33)	(2.25)	(2.29)	(2.00)	(2.04)	(2.17)	(2.21)
LSD(P=0.05)	0.49	0.51	0.23	0.22	0.08	0.09	0.91	0.09	0.08	0.08

The data in parentheses were transformed with square root transformation $\sqrt{x+0.5}$

Table 4. Dry weight of weeds (g/m^2) influenced by rice-based cropping system during *Rabi* season

Treatment	*Chenopodium album*		*Medicago denticulata*		*Polygonum plabeium*		*Echinochloa colona*		*Melilotus alba*	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
Cropping system										
Rice fallow	8.75	9.20	7.00	7.36	5.25	5.52	3.15	3.31	3.50	3.68
	(3.04)	(3.11)	(2.74)	(2.80)	(2.40)	(2.45)	(1.91)	(1.95)	(2.00)	(2.04)
Rice - wheat	18.20	19.14	477.75	502.36	47.60	50.05	7.35	7.73	43.75	46.00
	(4.32)	(4.43)	(21.87)	(22.42)	(6.94)	(7.11)	(2.80)	(2.87)	(6.65)	(6.82)
Rice - garden pea	21.00	22.08	22.75	23.92	31.15	32.75	1.05	1.10	7.00	7.36
	(4.64)	(4.75)	(4.82)	(4.94)	(5.63)	(5.77)	(1.24)	(1.26)	(2.74)	(2.80)
Rice - chickpea	15.75	16.56	12.25	12.88	23.80	25.03	0.70	0.74	13.65	14.35
	(4.03)	(4.13)	(3.57)	(3.66)	(4.93)	(5.05)	(1.10)	(1.11)	(3.76)	(3.85)
Rice - summer maize	3.50	3.68	8.75	9.20	3.50	3.68	3.50	3.68	0.70	0.74
	(2.00)	(2.04)	(3.04)	(3.11)	(2.00)	(2.04)	(2.00)	(2.04)	(1.10)	(1.11)
LSD (P=0.05)	1.04	1.08	0.31	0.32	0.40	0.42	0.81	0.84	0.91	0.93
Irrigation frequency										
2 irrigation	19.25	20.24	23.80	25.03	32.20	33.86	6.30	6.63	7.00	7.36
	(4.44)	(4.55)	(4.93)	(5.05)	(5.72)	(5.86)	(2.61)	(2.67)	(2.74)	(2.80)
4 irrigation	14.70	15.46	19.25	20.24	21.70	22.82	3.15	3.31	4.90	5.15
	(3.90)	(3.99)	(4.44)	(4.55)	(4.71)	(4.83)	(1.91)	(1.95)	(2.32)	(2.38)
6 irrigation	10.50	11.04	9.80	10.30	15.75	16.56	1.75	1.84	3.15	3.31
	(3.32)	(3.40)	(3.21)	(3.29)	(4.03)	(4.13)	(1.50)	(1.53)	(1.91)	(1.95)
LSD (P=0.05)	0.58	0.60	1.23	1.27	0.69	0.71	1.65	0.43	1.42	0.43

The data in parentheses were transformed with square root transformation $\sqrt{x+0.5}$

Table 5. Economics of rice-based cropping system influenced by different cropping system

Treatment	Rice equivalent yield (t/ha)		Gross return (x10³ `/ha)		Net returns (x10³ `/ha)		B:C ratio	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
Cropping system								
Rice-fallow	3.01	3.63	30.12	32.83	25.62	27.67	2.85	2.92
Rice-wheat	5.42	11.75	54.20	59.08	47.20	50.98	4.10	4.22
Rice-garden pea	6.61	17.49	66.13	72.08	58.63	63.32	4.89	5.02
Rice-chickpea	7.20	20.76	72.04	78.52	63.43	68.50	4.84	4.97
Rice-summer maize	4.83	9.32	48.26	52.60	40.16	43.37	3.19	3.27
LSD(P=0.05)	1.78	2.01	0.18	19.45	16.23	17.53	0.76	0.81
Irrigation frequency								
2 irrigation	4.21	7.11	42.15	45.94	34.65	37.42	2.89	2.97
4 irrigation	5.02	10.10	50.25	54.77	42.26	45.64	3.38	3.48
6 irrigation	6.82	18.63	68.24	74.38	59.99	64.79	4.71	4.83
LSD(P=0.05)	1.80	8.53	0.017	19.61	17.73	19.14	1.33	1.35

to be significantly higher in accumulation of dry matter and no single cropping system was able to beat this level under rice-wheat cropping system except *E. colona* under rice-summer maize in *Rabi* season. The reverse trend was noticed in *Rabi* season as compared to *Kharif*, where less irrigation had higher dry matter of weeds and it was reduced with increasing frequency of irrigation. Therefore, six irrigation reduced drastic reduction of dry matter accumulation in *Rabi* weeds as they did not have the capacity to tolerant six frequency of irrigation. This may help to lowering weed competition in crops especially in later stage. This result indicated that incorporation of succeeding crops in *Rabi* season as in rice-fallow contributed more than alone. This might be owing to higher total productivity than rice-fallow cropping system. The above results were in conformity with the findings reported by Reddy and Suresh (2008) and Sarkar and Gangwar (1998).

Economic analysis

The highest rice equivalent yield (7.72-7.76 t/ha) under rice-chickpea cropping system was significantly superior over rest of cropping system and was at par with rice-wheat (5.42 and 5.75 t/ha) and rice-garden pea (6.61. and 6.49 t/ha) during 2008-09 and 2009-10. The gross returns were also higher in the system of cropping because of higher value of produce. The rice-chickpea cropping system fetched gross return of ` 72,040 and 78,523/ha/annum followed by rice-chickpea and rice-wheat cropping systems. The net profitability was higher in rice-chickpea cropping system due to higher gross return. Similar trend was noticed for higher B:C ratio with rice-chickpea cropping system (4.84 and 4.97). The inclusion of *Rabi* crops in fallow sequences could boost the profitability of cropping system. These results confirm the findings of Samui *et al.* (2004).

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